Madden-Julian Oscillation: Recent Evolution, Current Status and Predictions

Update prepared by
Climate Prediction Center / NCEP
June 16, 2014

Outline

- Overview
- Recent Evolution and Current Conditions
- MJO Index Information
- MJO Index Forecasts
- MJO Composites

Overview

- The amplitude of MJO indices increased during the previous week, however, the lack of eastward propagation indicates that subseasonal factors other than a coherent MJO are driving the pattern of anomalous tropical convection.

- There is considerable spread among dynamical MJO index model forecasts, with some showing a weakening MJO signal while others shift the signal rapidly to the western Pacific. Statistical models favor an eastward propagation more consistent with MJO activity.

- Based on recent observations and the high uncertainty illustrating by the dynamical model forecasts, the MJO is forecast to remain generally weak while other types of tropical variability including conditions favoring enhanced convection over the central Pacific strongly influence the pattern.

- The MJO may contribute some to enhanced rainfall across parts of southeast Asia, the Maritime Continent, and the far western Pacific during the upcoming week.

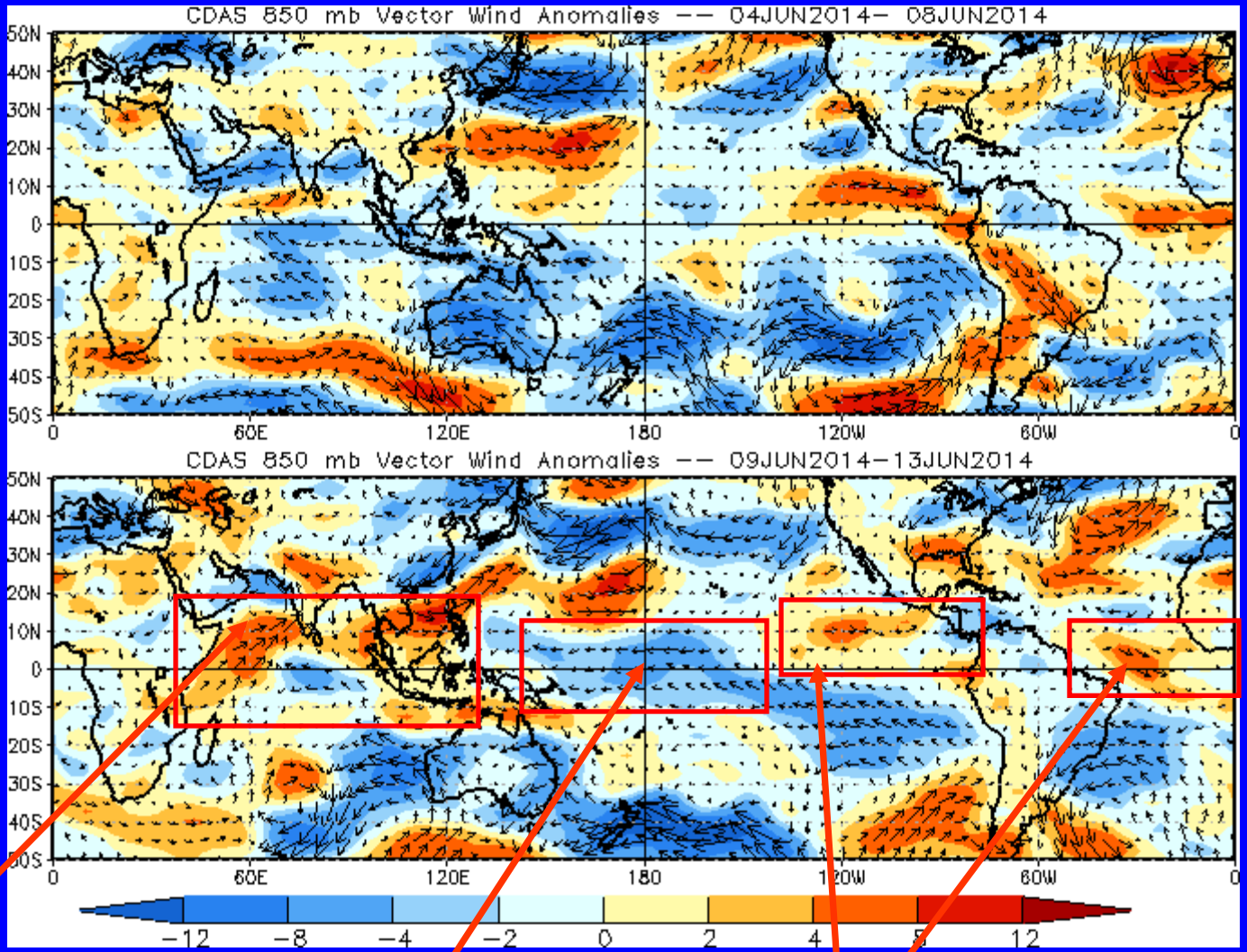
Additional potential impacts across the global tropics and a discussion for the U.S. are available at:
http://www.cpc.ncep.noaa.gov/products/precip/CWlink/ghazards/index.php

850-hPa Vector Wind Anomalies (m s^{-1})

Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

Red shades: Westerly anomalies



Westerly anomalies developed over the western and northern Indian Ocean and the western Maritime Continent.

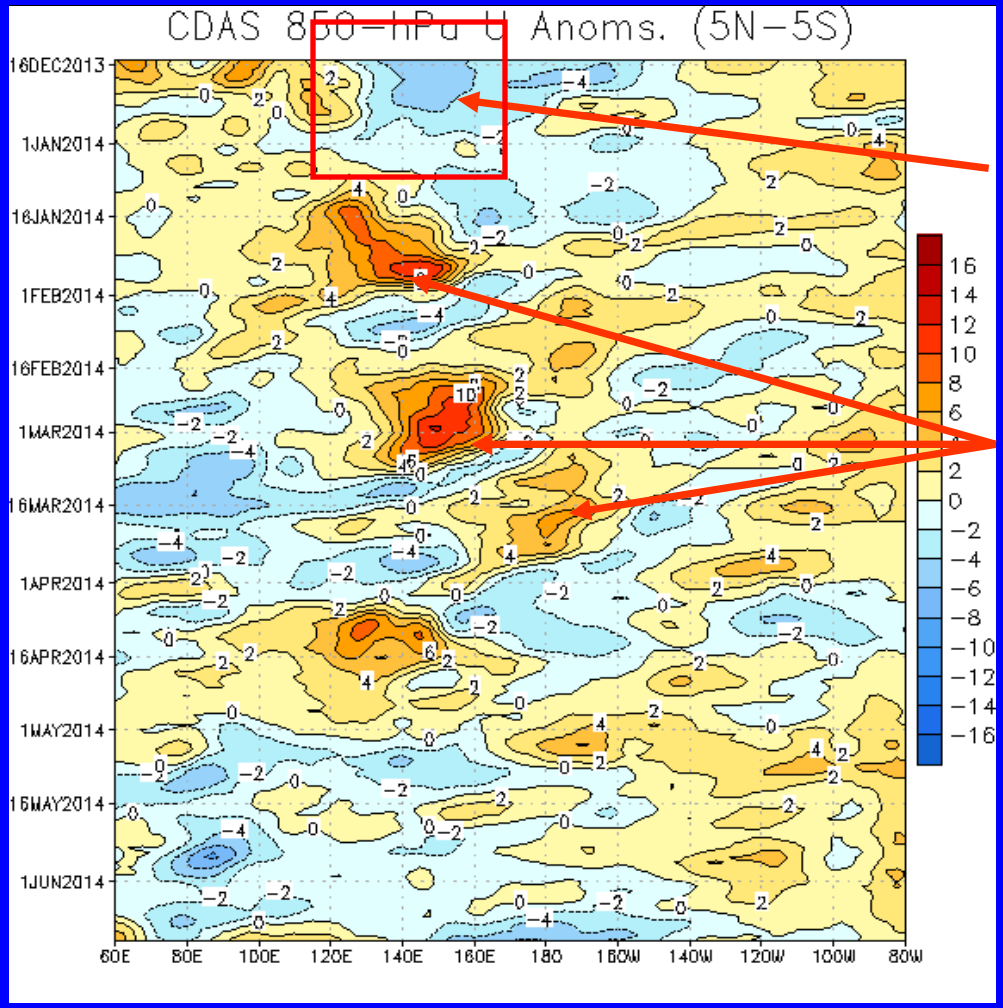
Easterly anomalies intensified near the Date Line along the equator over the west-central Pacific.

Westerly anomalies persisted over the eastern Pacific and Atlantic basins during the most recent five days.

850-hPa Zonal Wind Anomalies (m s^{-1})

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow



Time

Longitude

Easterly anomalies dominated from 120E to near the Date Line during December 2013 as MJO activity was weak.

Multiple westerly wind bursts were observed across the western Pacific between January and mid-March. Each westerly wind burst shifted slightly further east.

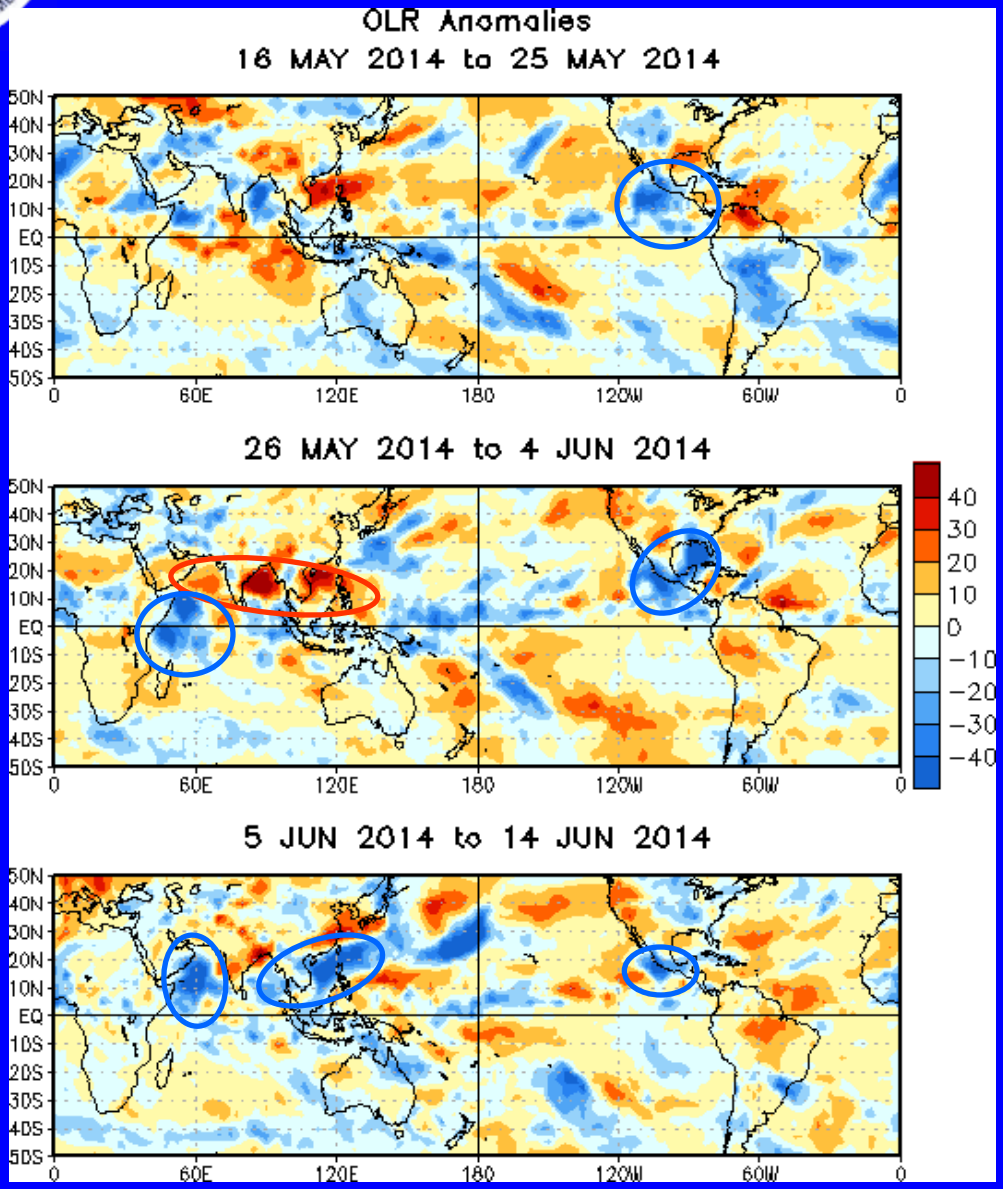
During April, westerly anomalies were generally persistent across the Maritime continent and far western Pacific.

During much of May and early June, westerly anomalies were observed over the eastern Pacific and Atlantic. More recently, westerly (easterly) anomalies developed over the eastern Indian Ocean and Maritime Continent (western and central Pacific).

OLR Anomalies – Past 30 days

Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

Wetter-than-normal conditions, negative OLR anomalies (blue shading)

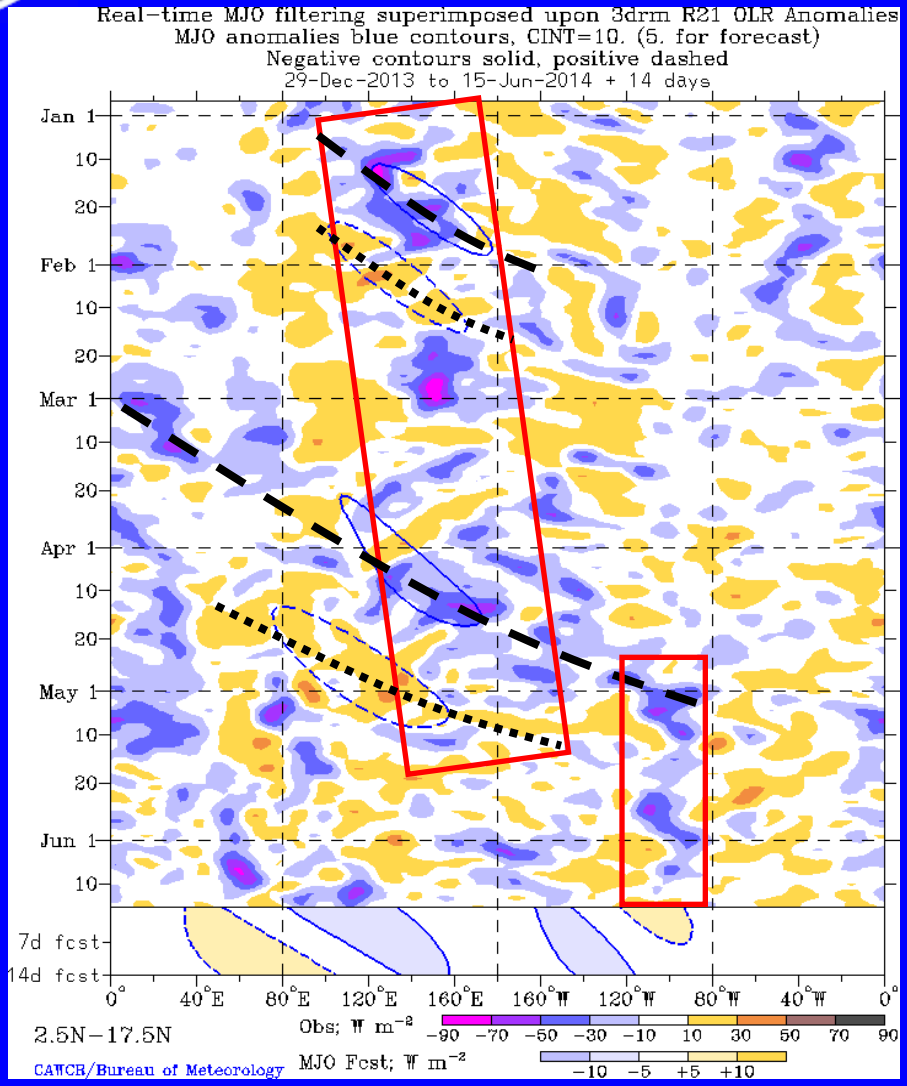


Few large-scale convective anomalies were observed in the pattern during mid to late May, although enhanced convection persisted over the eastern Pacific basin.

During late May into early June, enhanced convection associated in part with tropical cyclone activity persisted over the eastern Pacific, while enhanced (suppressed) convection was observed over parts of the western Indian Ocean (Arabian Sea, Bay of Bengal, and the South China Sea).

During early to mid-June, enhanced convection was observed over the Arabian Sea and Southeast Asia. Enhanced convection associated with tropical cyclone activity persisted over a small area of the eastern Pacific.

Outgoing Longwave Radiation (OLR) Anomalies (2.5°N-17.5°N)



Time

Longitude

Drier-than-normal conditions, positive OLR anomalies (yellow/red shading)

Wetter-than-normal conditions, negative OLR anomalies (blue shading)

(Courtesy of CAWCR Australia Bureau of Meteorology)

From January through April, enhanced convection propagated slowly eastward from the Maritime Continent to the western Pacific (red box), interrupted by positive OLR anomalies during late January and early February and again in March associated with the MJO.

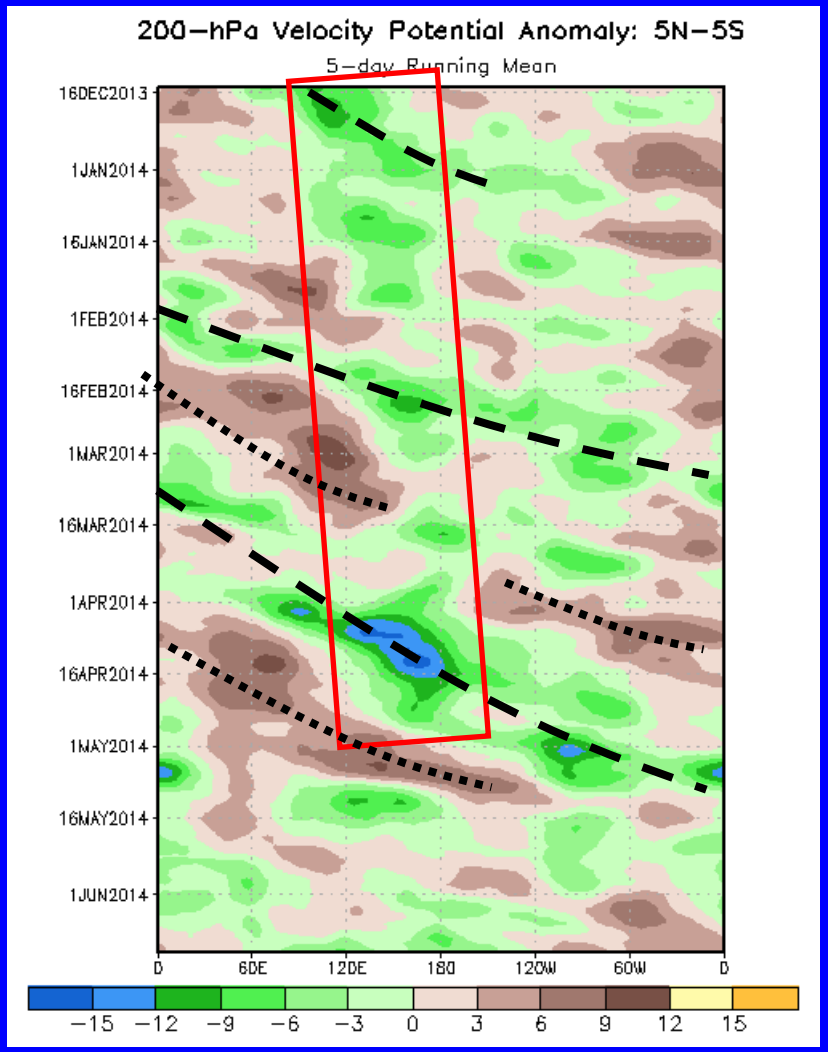
The MJO became more coherent during April, with the subseasonal envelopes of enhanced and suppressed convection modulating the strength of the low frequency signal.

The pattern of anomalous tropical convection became largely incoherent during mid-May, with persistent convection observed over the eastern Pacific (red box). More recently, areas of enhanced convection were observed over parts of the Indian Ocean and Maritime Continent.

200-hPa Velocity Potential Anomalies (5°S-5°N)

Positive anomalies (brown shading) indicate unfavorable conditions for precipitation

Negative anomalies (green shading) indicate favorable conditions for precipitation



Time

Longitude

The enhanced phase of the MJO was evident during December (dashed black line) as negative anomalies propagated from the Indian Ocean to near the Date Line. No clear suppressed was evident thereafter.

At this time, a slow eastward progression of negative anomalies was observed from late December to the present across the Indo-Pacific warm pool region (red box).

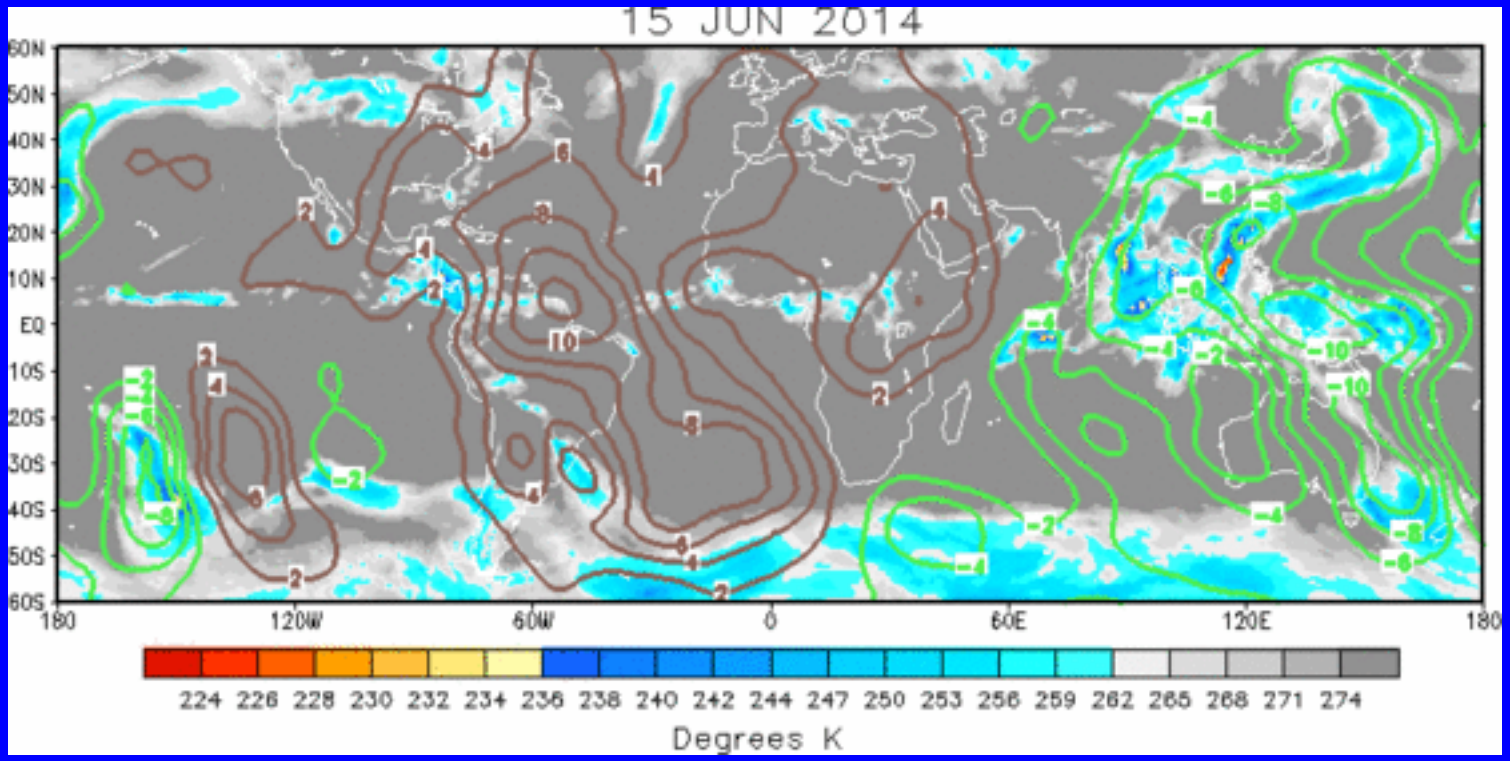
During February into early March, anomalies propagated eastward with time associated with the MJO before weakening.

The MJO strengthened once again during April as eastward propagation of both positive and negative anomalies are indicated. This signal weakened more recently in favor of higher frequency Kelvin waves.

IR Temperatures (K) / 200-hPa Velocity Potential Anomalies

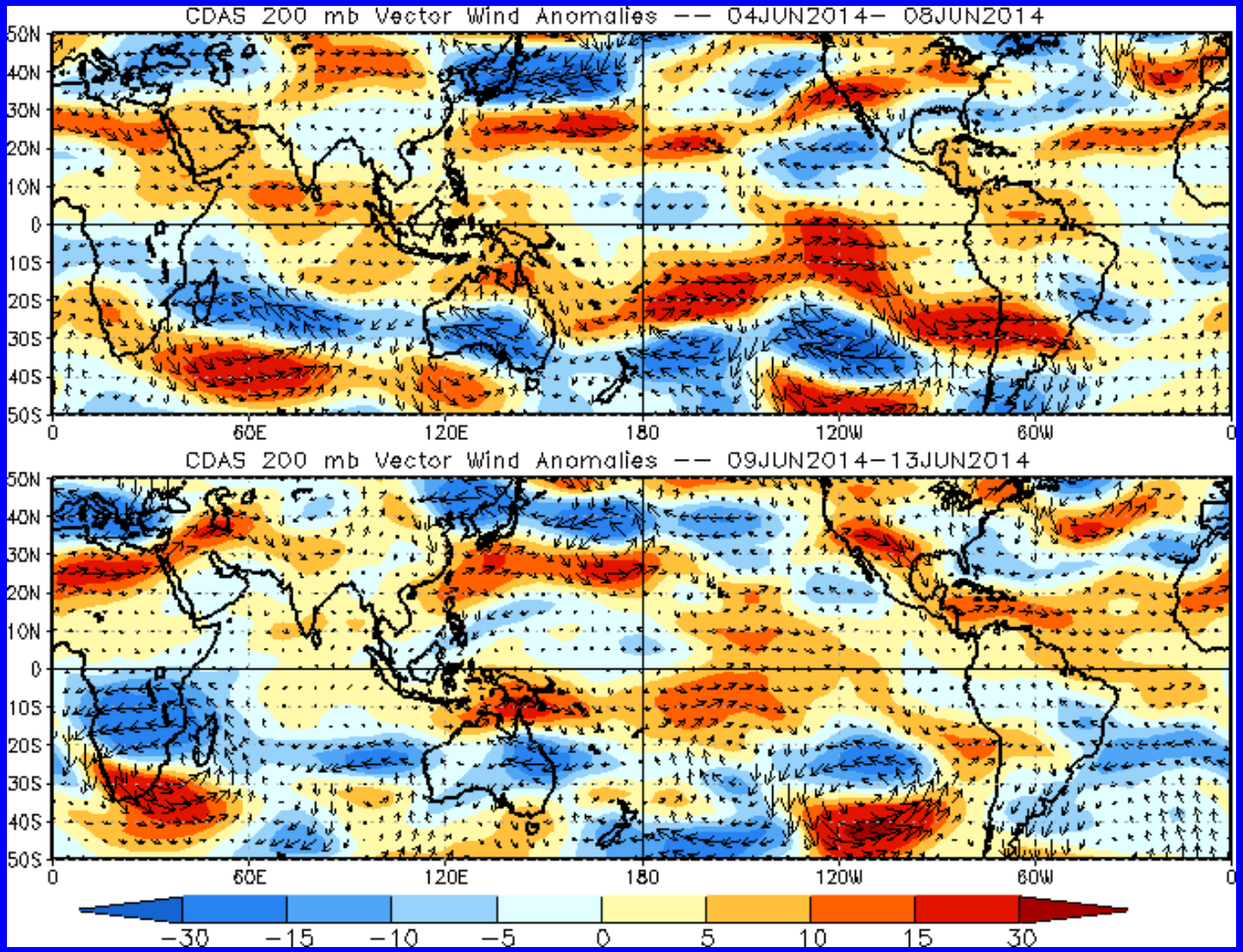
Positive anomalies (brown contours) indicate unfavorable conditions for precipitation

Negative anomalies (green contours) indicate favorable conditions for precipitation



The upper-level anomalous velocity potential spatial pattern has become more coherent, with large scale negative (positive) anomalies over the eastern Indian Ocean, Maritime Continent, and far western Pacific (Americas to Africa). Generally weak anomalies were observed across the remainder of the tropical Pacific.

200-hPa Vector Wind Anomalies (m s^{-1})



Note that shading denotes the zonal wind anomaly

Blue shades: Easterly anomalies

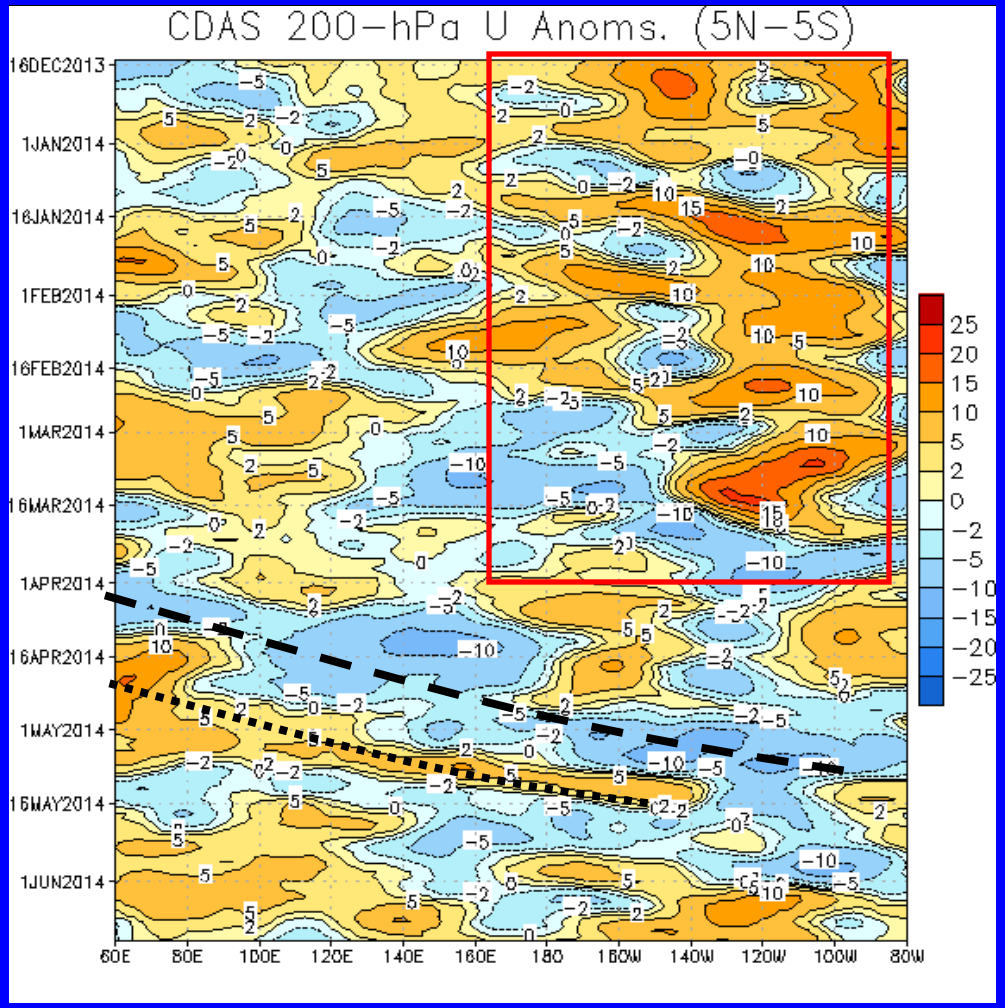
Red shades: Westerly anomalies

Westerly anomalies weakened over the Indian Ocean, while westerly anomalies propagated westward over the central Pacific during the previous 10 days.

200-hPa Zonal Wind Anomalies (m s^{-1})

Westerly anomalies (orange/red shading) represent anomalous west-to-east flow

Easterly anomalies (blue shading) represent anomalous east-to-west flow



Time

Longitude

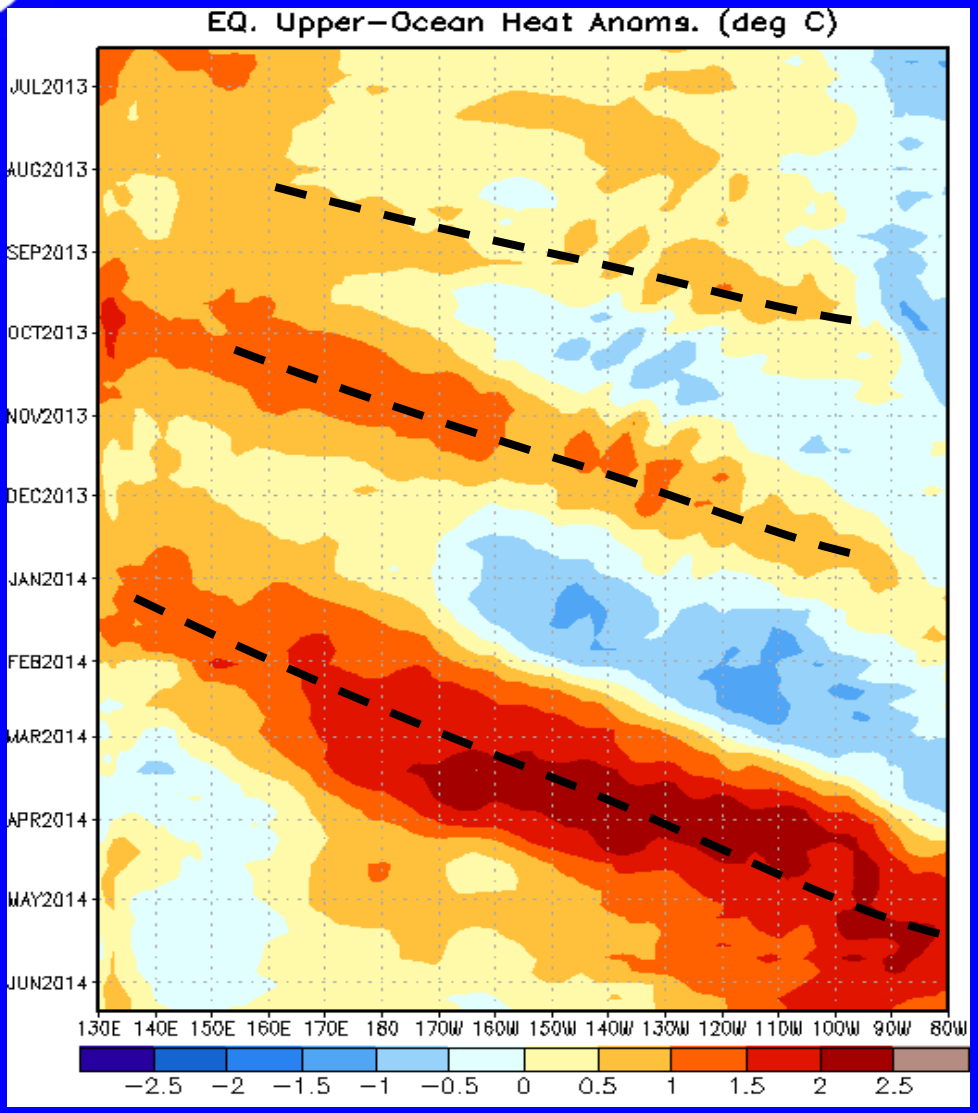
From December into March, westerly anomalies were most prevalent across the western Hemisphere (red box).

During mid-April, the slowly evolving background state has contributed to easterly anomalies expanding to the Date Line.

Recent MJO activity is evident in the eastward propagation of both easterly and westerly anomalies during April and early May. This signal weakened during late May.

Westward propagation of westerly anomalies is evident over the east central Pacific.

Weekly Heat Content Evolution in the Equatorial Pacific



Time

Longitude

Oceanic downwelling Kelvin wave activity is evident in late August 2013 and once again during October through early December 2013.

A considerably stronger downwelling event began in January 2014 and propagated across the Pacific.

Warm anomalies persisted over much of the Pacific from April through early June.

MJO Index -- Information

- The MJO index illustrated on the next several slides is the CPC version of the Wheeler and Hendon index (2004, hereafter WH2004).

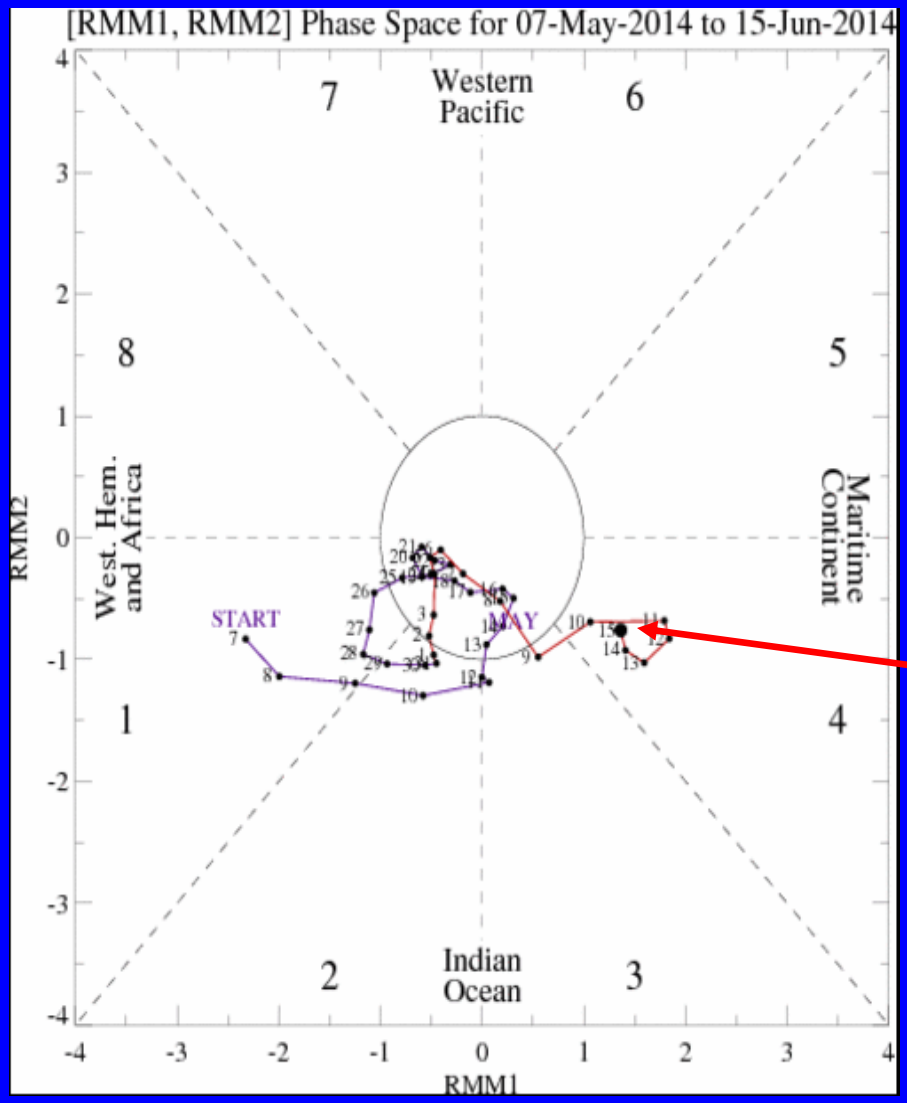
Wheeler M. and H. Hendon, 2004: An All-Season Real-Time Multivariate MJO Index: Development of an Index for Monitoring and Prediction, *Monthly Weather Review,* 132, 1917-1932.

- The methodology is very similar to that described in WH2004 but does not include the linear removal of ENSO variability associated with a sea surface temperature index. The methodology is consistent with that outlined by the U.S. CLIVAR MJO Working Group.

Gottschalck et al. 2010: A Framework for Assessing Operational Madden-Julian Oscillation Forecasts: A CLIVAR MJO Working Group Project, *Bull. Amer. Met. Soc.*, 91, 1247-1258.

- The index is based on a combined Empirical Orthogonal Function (EOF) analysis using fields of near-equatorially-averaged 850-hPa and 200-hPa zonal wind and outgoing longwave radiation (OLR).

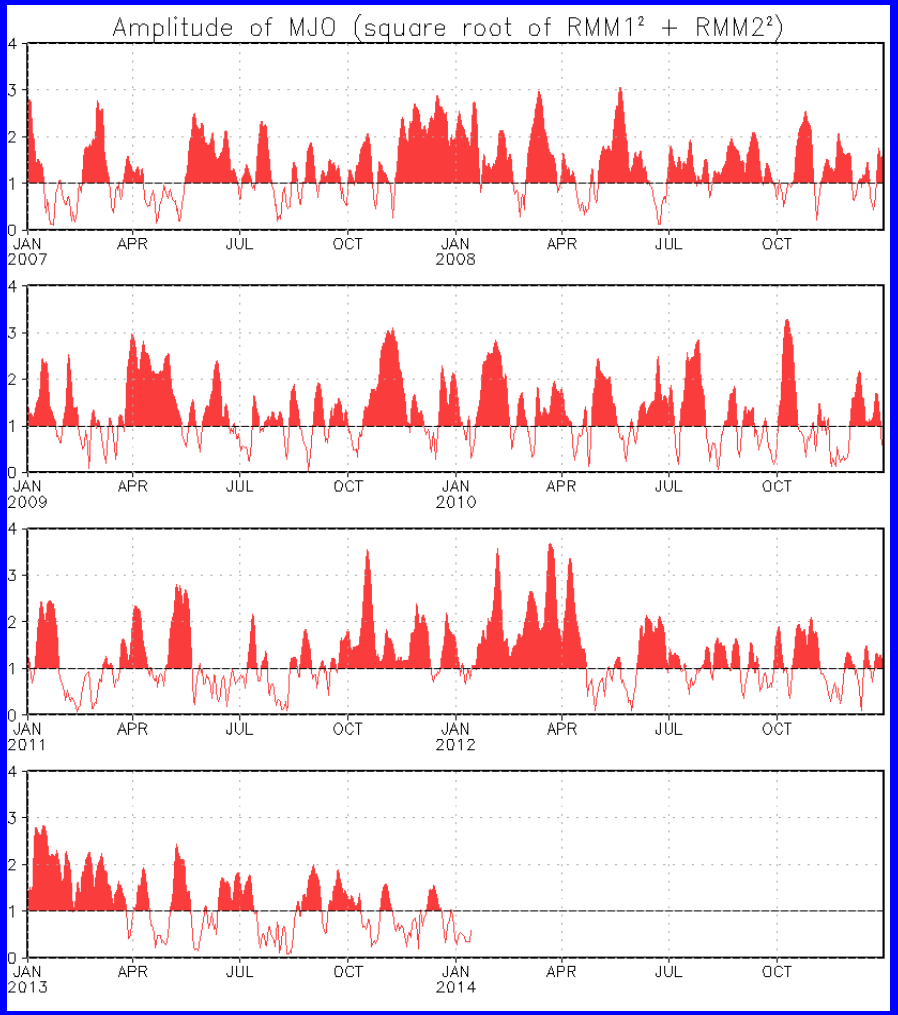
MJO Index -- Recent Evolution



- The axes (RMM1 and RMM2) represent daily values of the principal components from the two leading modes
- The triangular areas indicate the location of the enhanced phase of the MJO
- Counter-clockwise motion is indicative of eastward propagation. Large dot most recent observation.
- Distance from the origin is proportional to MJO strength
- Line colors distinguish different months

The MJO index shows strong amplitude over the Maritime Continent with no eastward propagation evident.

MJO Index – Historical Daily Time Series



Time series of daily MJO index amplitude from 2007 to present.

Plot puts current MJO activity in recent historical context.

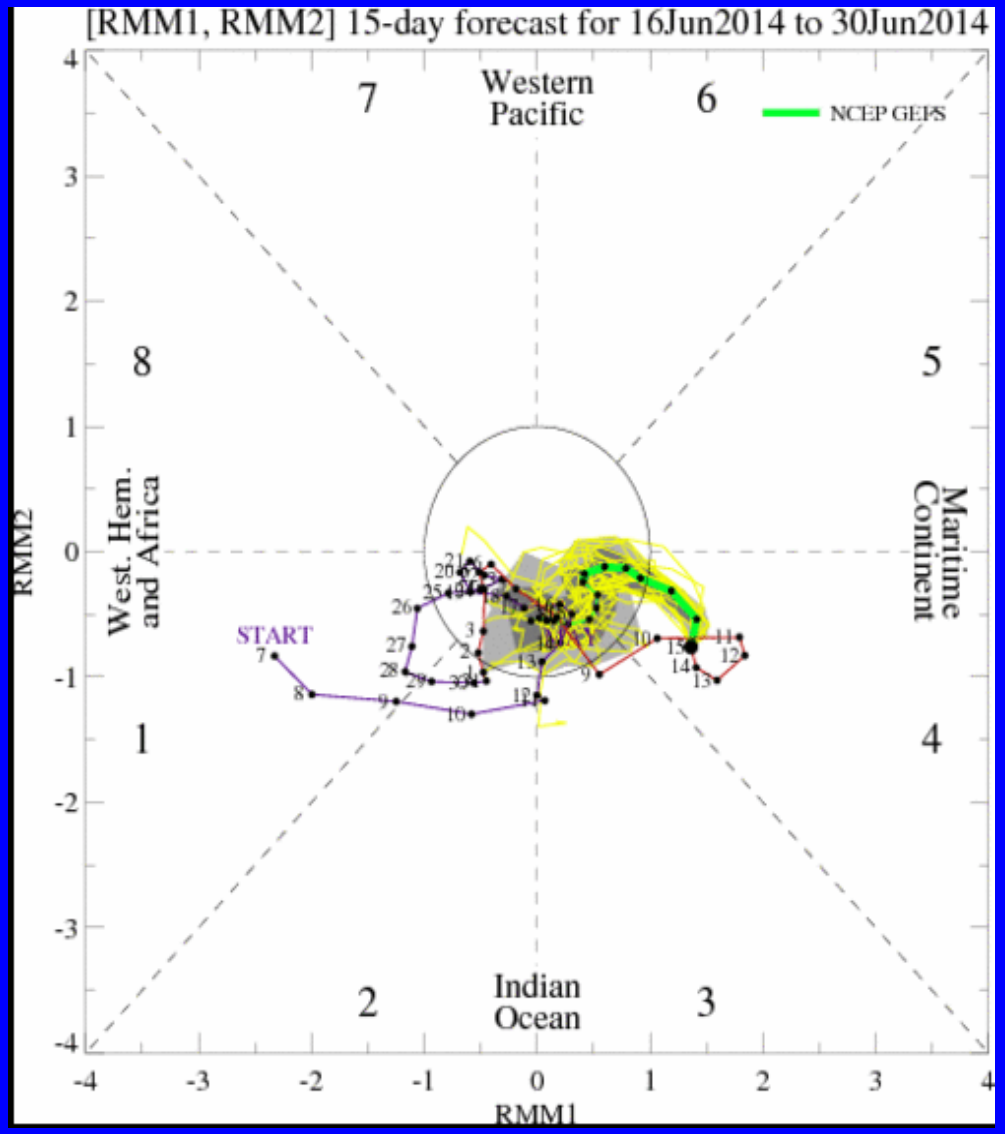
Ensemble GFS (GEFS) MJO Forecast

Yellow Lines – 20 Individual Members
Green Line – Ensemble Mean

RMM1 and RMM2 values for the most recent 40 days and forecasts from the ensemble Global Forecast System (GEFS) for the next 15 days

light gray shading: 90% of forecasts
dark gray shading: 50% of forecasts

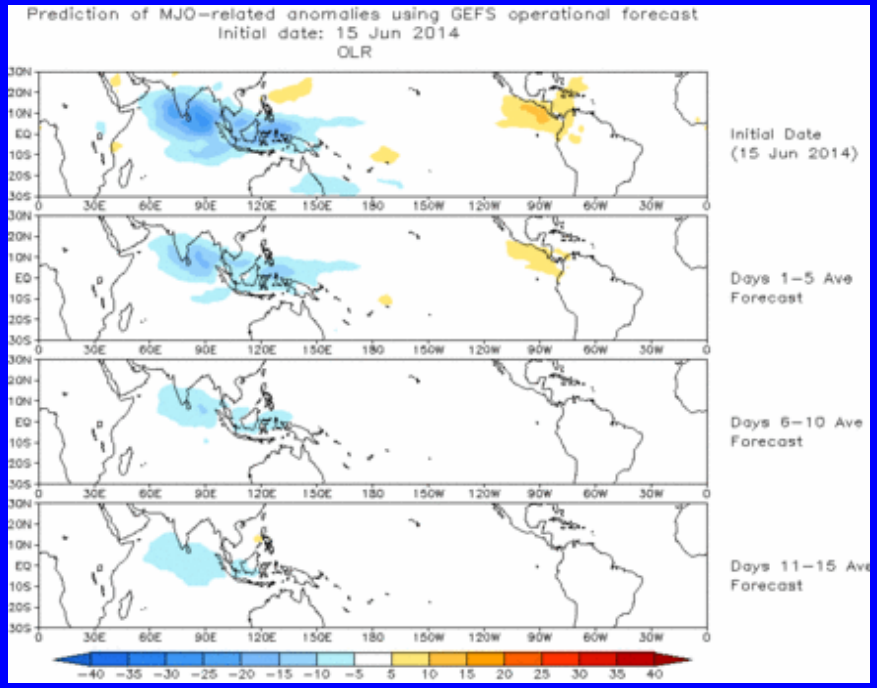
The ensemble GFS forecast indicates a weakening of amplitude with no eastward propagation on the MJO RMM Index during the next two weeks.



Ensemble Mean GFS MJO Forecast

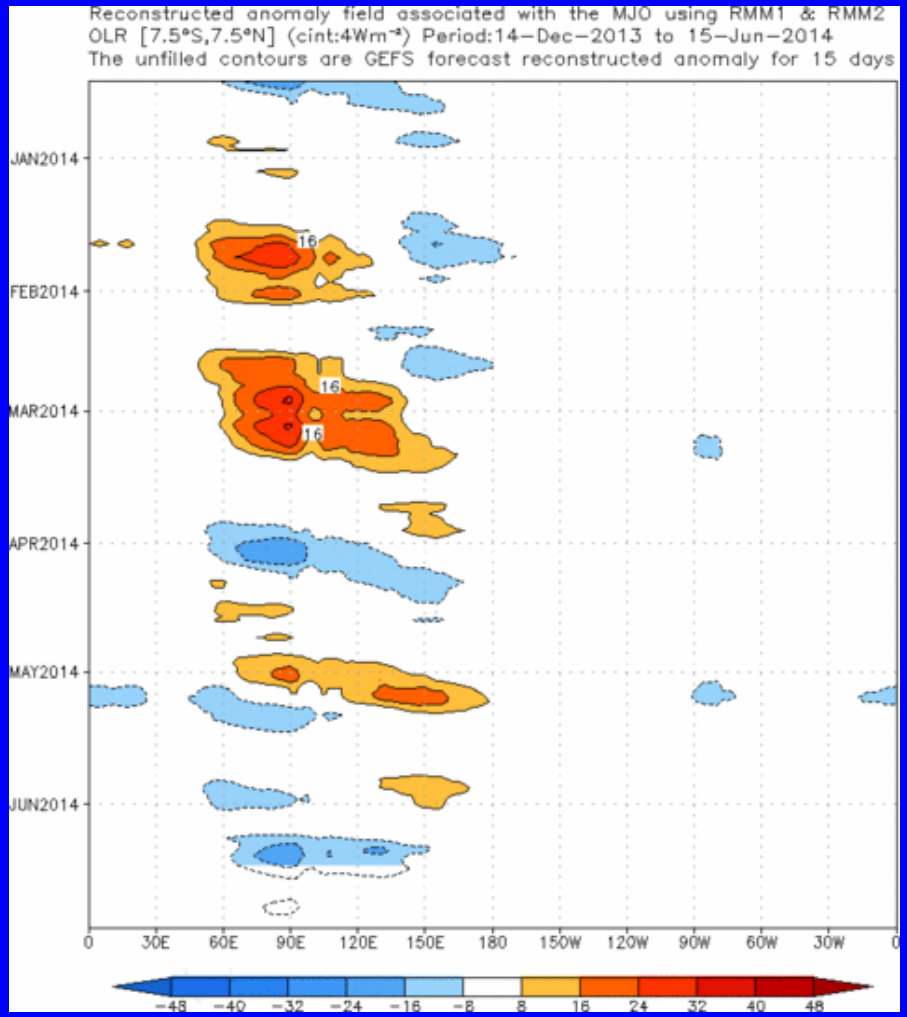
Figures below show MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



The ensemble mean GFS forecasts enhanced (suppressed) convection persisting over the northern Indian Ocean and Maritime Continent (eastern Pacific and central America) during the upcoming two weeks.

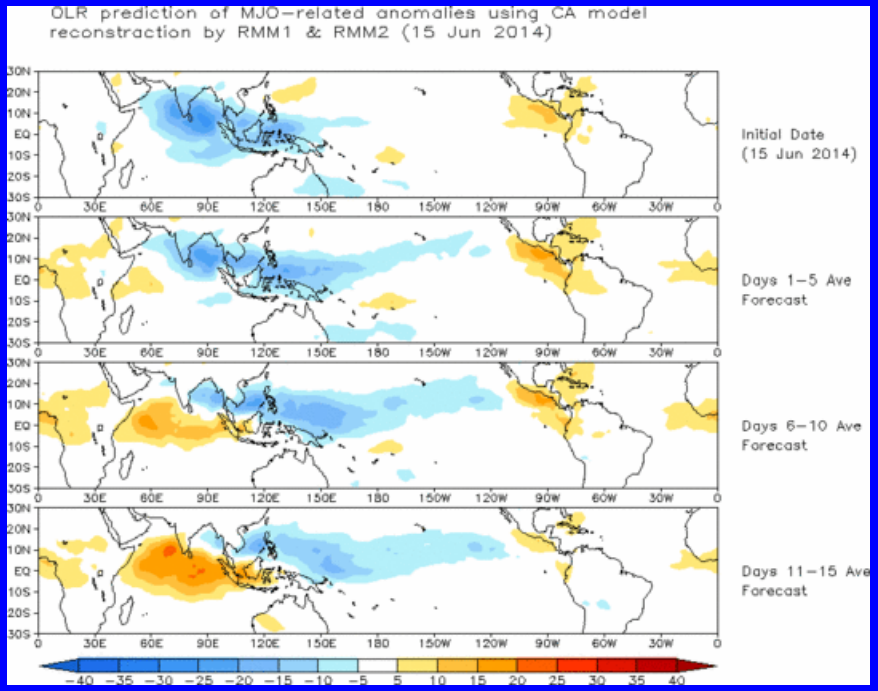
Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days



Constructed Analog (CA) MJO Forecast

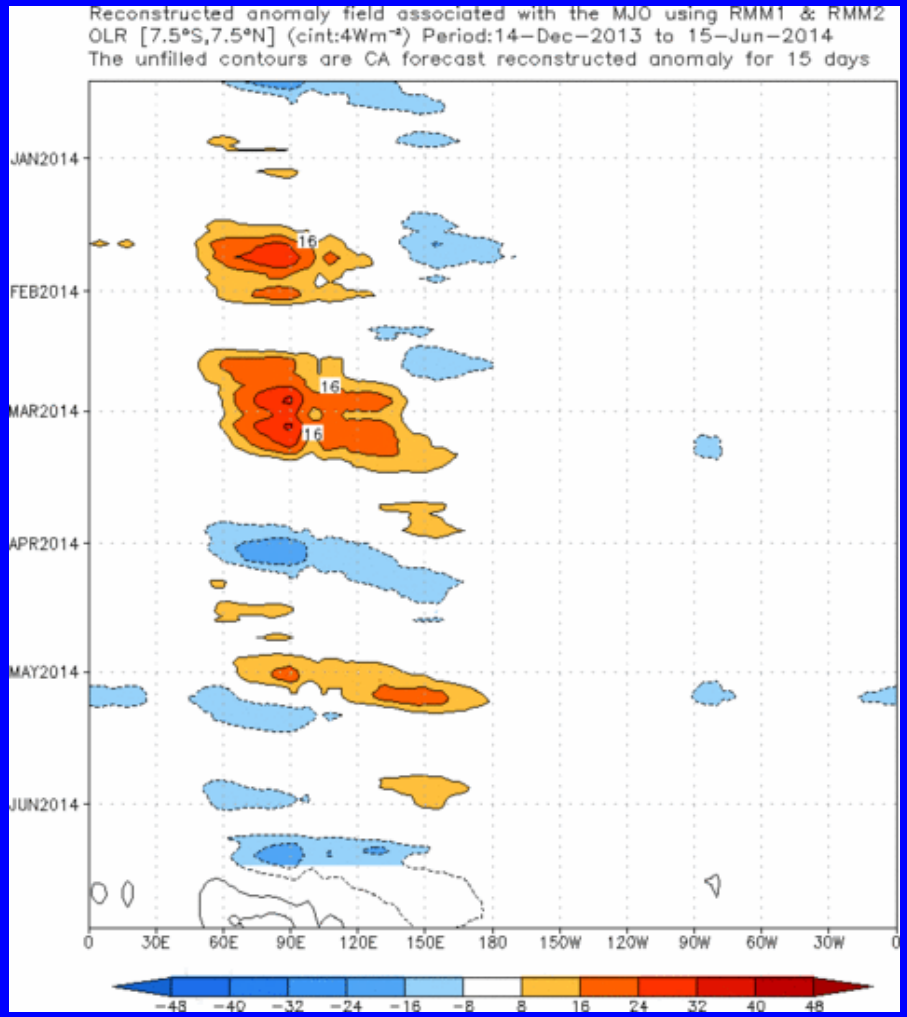
Figure below shows MJO associated OLR anomalies only (reconstructed from RMM1 and RMM2) and do not include contributions from other modes (*i.e.*, ENSO, monsoons, etc.)

Spatial map of OLR anomalies for the next 15 days



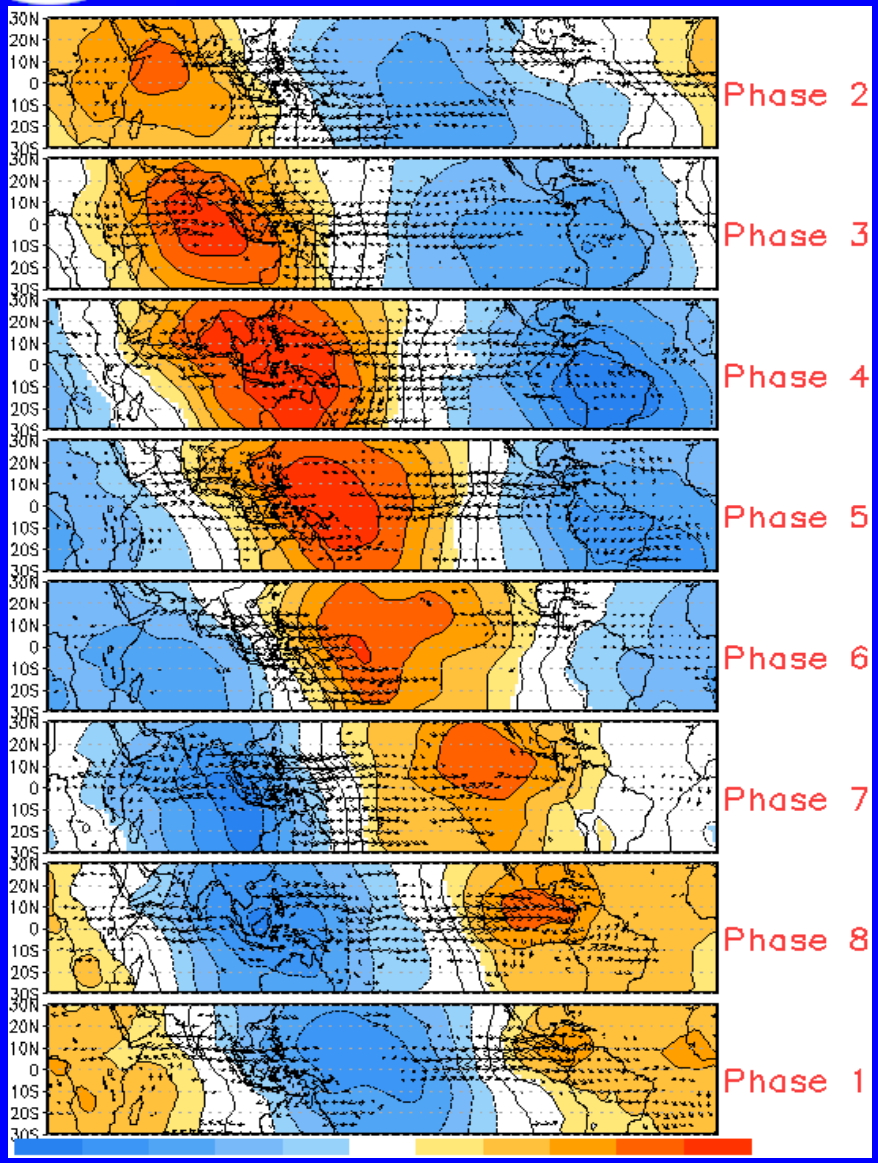
The constructed analog MJO forecast depicts a much more robust eastward propagation of convective anomalies.

Time-longitude section of (7.5°S-7.5°N) OLR anomalies for the last 180 days and for the next 15 days

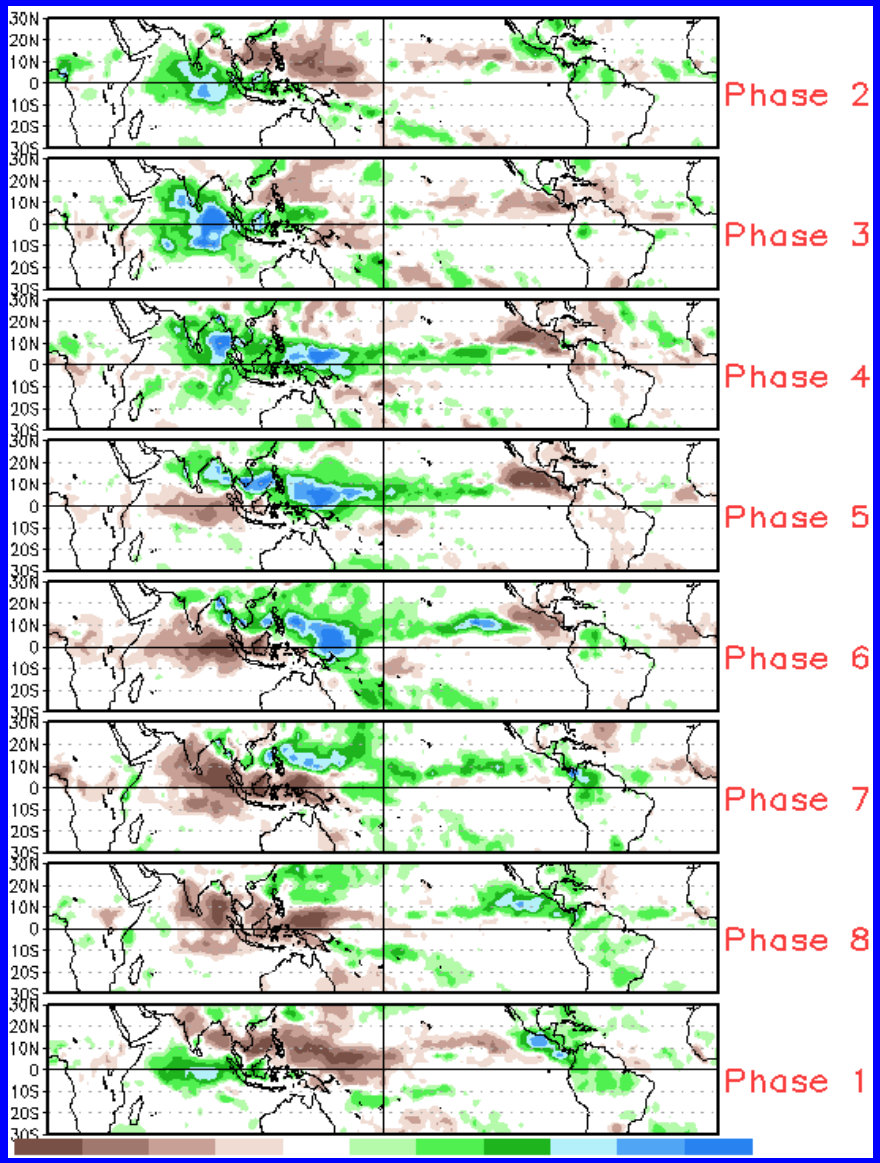


MJO Composites – Global Tropics

850-hPa Velocity Potential and Wind Anomalies (May-Sep)

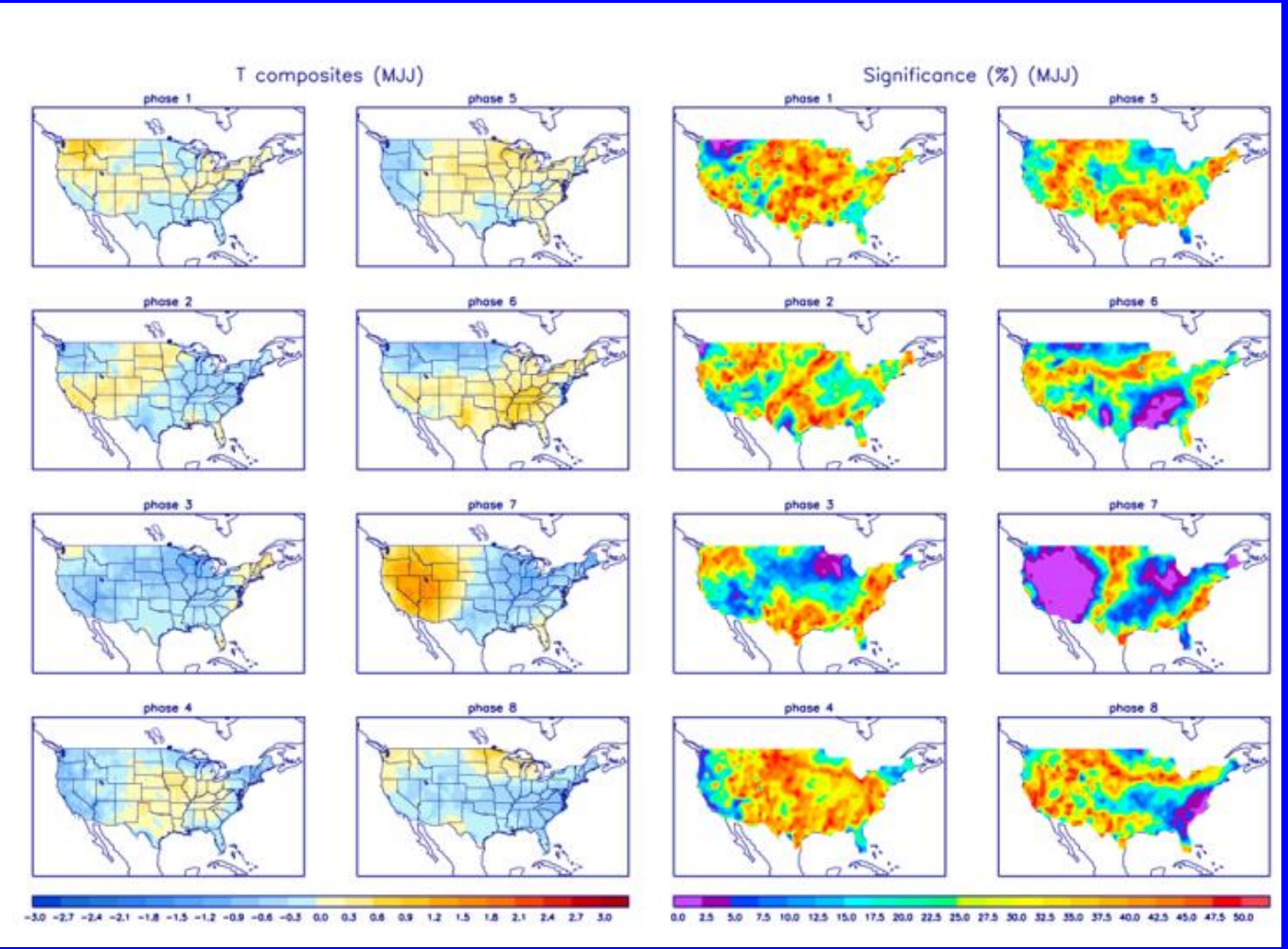


Precipitation Anomalies (May-Sep)



U.S. MJO Composites – Temperature

- **Left hand side plots show temperature anomalies by MJO phase for MJO events that have occurred over the three month period in the historical record. Blue (orange) shades show negative (positive) anomalies respectively.**
- **Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.**

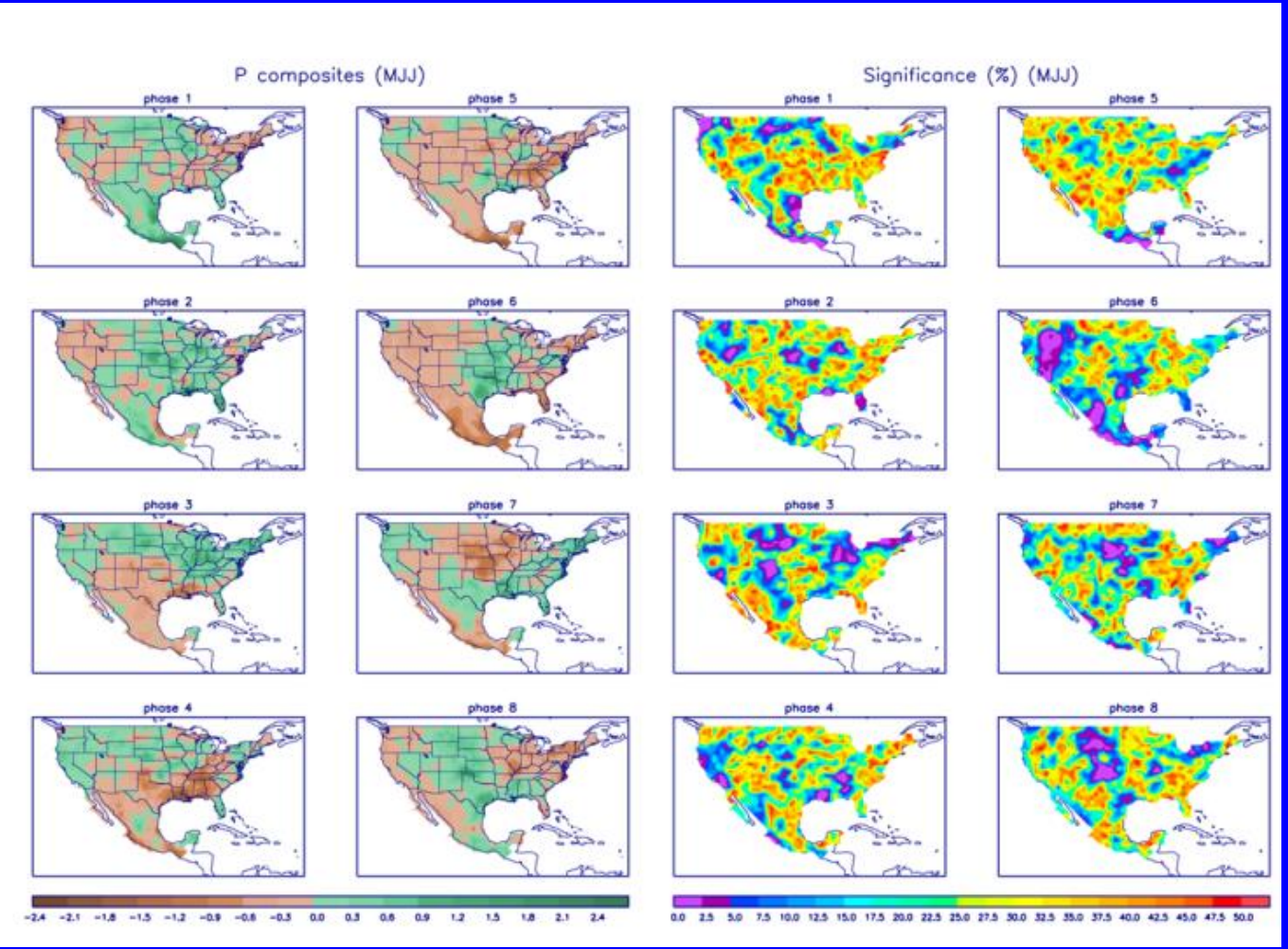


Zhou et al. (2011): A composite study of the MJO influence on the surface air temperature and precipitation over the Continental United States, *Climate Dynamics*, 1-13, doi: 10.1007/s00382-011-1001-9

http://www.cpc.ncep.noaa.gov/products/precip/CWlink/MJO/mjo.shtml

U.S. MJO Composites – Precipitation

- **Left hand side plots show precipitation anomalies by MJO phase for MJO events that have occurred over the three month period in the historical record. Brown (green) shades show negative (positive) anomalies respectively.**
- **Right hand side plots show a measure of significance for the left hand side anomalies. Purple shades indicate areas in which the anomalies are significant at the 95% or better confidence level.**



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